

Resurgence of Nuclear Energy in the US *and what it could mean for spent fuel management*

Nevada Local Section of ANS

Las Vegas

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&

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US nuclear generation: 104 reactors; 100 GWe; 2000 t SNF/year

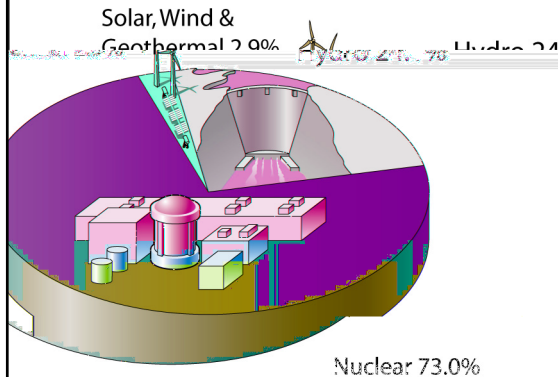


Today's operating
plants are
"Generation-II"



Nuclear generates most of America's emission free electricity

Sources of Emission-Free Electricity



Worldwide nuclear plants save more than twice the Kyoto carbon target annually.

In the US, nuclear plants avoid tons of emissions:

- 3.4 million tons of sulfur dioxide
- 1.1 million tons of nitrous oxides
- 700 million tons of carbon dioxide

Consolidation of nuclear ownership



Last 5 years

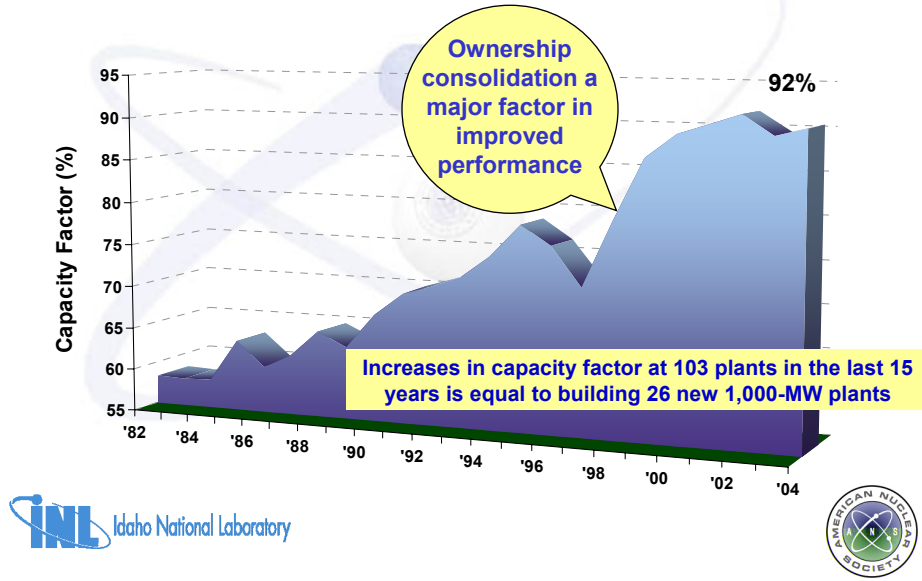
- Substantial consolidation
- Top 10 operators have 61% of nuclear market
- Top 5 operators have 42% of nuclear market

Consolidation of Ownership

resulted

- Corporate mergers and acquisitions
- Asset sales by companies desiring to exit nuclear ownership

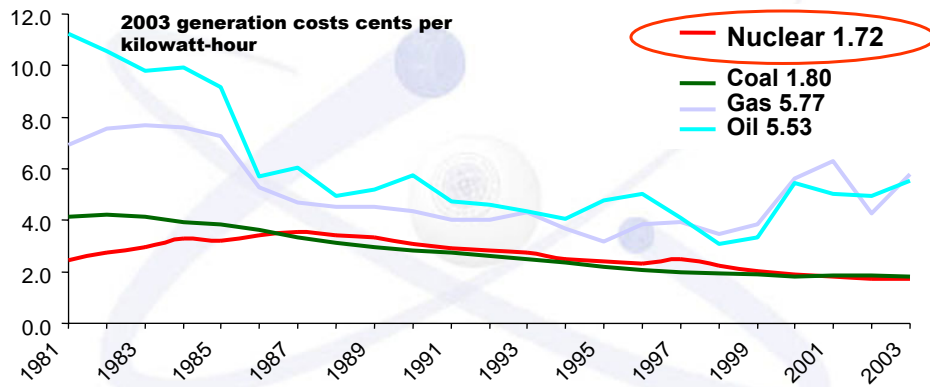
Nuclear power's proven performance in US



Performance improvements since President Carter's administration

Performance indicator	1979	Today
No. of commercial reactors	69	103
Electricity produced (kilowatt-hours)	255 billion	789 billion
Fleet average capacity factor	56.3%	90.5%
Unplanned reactor shutdowns/7000 hr	7.3%	0
Industrial safety accident rate/200k-hr	2.1	0.25

Nuclear energy is competitive



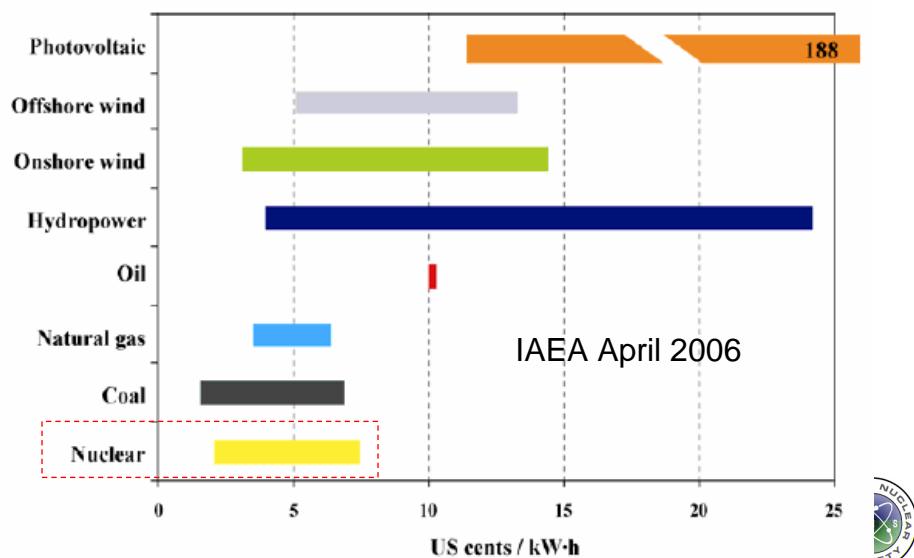
Nuclear is the lowest cost of all (except hydro)



Nuclear Energy Institute



Results of 7 recent forward cost studies



Entergy's look at the MIT economic study

New Nuclear (LWR, \$/MWH)				\$67
- Reduce Construction Cost, \$2,000 to \$1500/KW	- \$12			55
- Reduce Construction Time, 5 to 4 Years	-2			53
- Reduce O&M plus Fuel, \$15 to 13/MWH	-2			51
- Reduce Cost of Capital, 15% to 12%	-9			42
- Increase Capacity Factor (90%)	-2			40
Carbon Tax Effect (\$/MWH)	\$0/tn	\$50/tn	\$100/tn	\$200/tn
Pulverized Coal	42	54	66	90
CCGT (Low Gas \$3.77/MCF)	38	43	48	59
CCGT (Moderate Gas \$4.42/MCF)	41	47	52	62
CCGT (High Gas \$6.72/MCF)	56	61	67	77

Courtesy of Dan Keuter

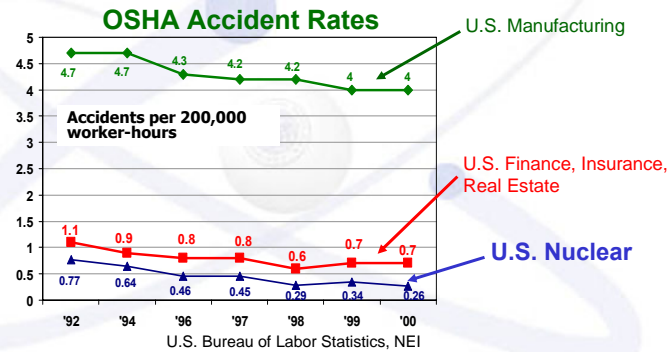


Significant financial investment

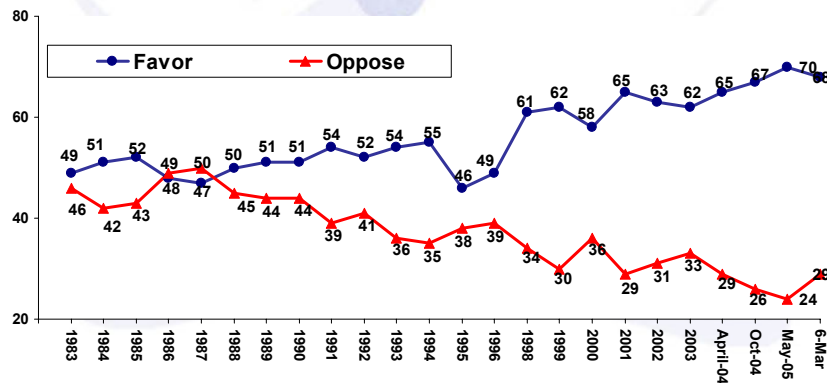
- \$5.4 billion for purchase of Westinghouse
- \$5.2 billion financial commitment to NRG to build 2 ABWRs at South Texas site
- Multi-hundred million \$\$\$ investment by major vendors (AREVA, Westinghouse, GE) in design certification by the NRC.
- Private equity investment? (e.g., sale of BNFL America to Energy Solutions)
- Favorable financial analyses by OECD, University of Chicago, and many others



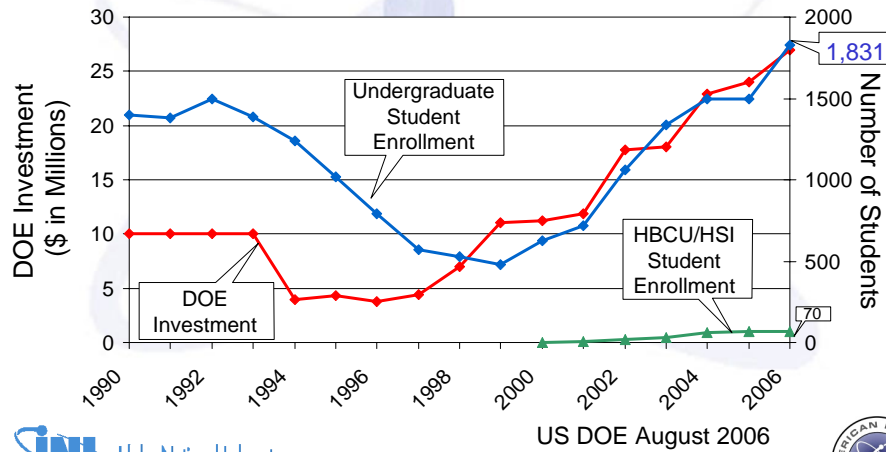
Nuclear energy has a strong safety record



Nuclear Energy widely favored in USA



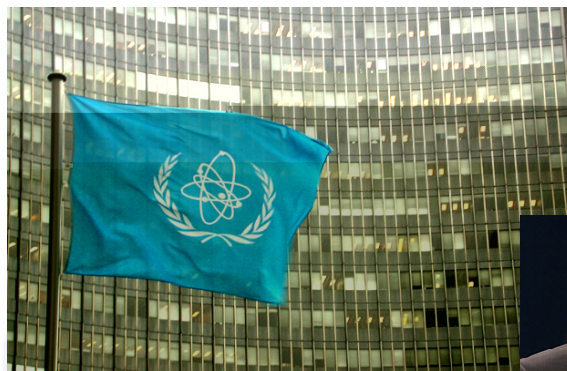
Trends in nuclear engineering enrollment



INL Idaho National Laboratory



Better international alignment on nuclear nonproliferation goals



...atoms for peace.
2005 Nobel Peace Prize



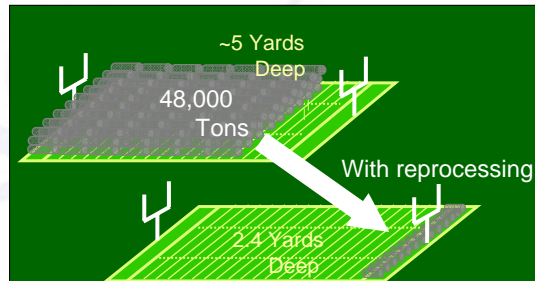
INL Idaho National Laboratory



Total amount of used fuel generated is relatively small and readily manageable

Current high-level waste volume after 40 years of operations would fill an area about the size of a football field five yards deep

- ~48,000 metric tons
- ~½ ton per fuel assembly
- ~ 100,000 assemblies
- Only ~5% is waste

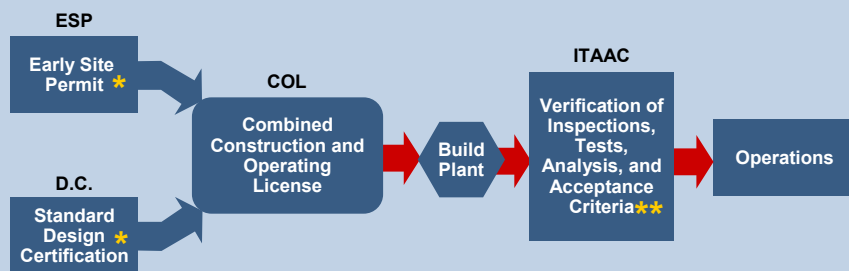


EPACT 2005 provisions for new plant construction

Loan guarantees	80% of project cost	<ul style="list-style-type: none"> Higher leverage Lower debt cost
Production tax credit	\$18/MW hr	<ul style="list-style-type: none"> Through 2021 \$125M/1000 MW per year 6,000 MW eligible IRS rule making: February 2006
Risk assurance	Delay protection	<ul style="list-style-type: none"> \$500M for 1st 2 plants \$250M for next 4 plants
Price-Anderson	Liability insurance	<ul style="list-style-type: none"> Reauthorization for 20 years
Decommissioning funds	Updates for treatment	<ul style="list-style-type: none"> Allows companies to establish funds and make contributions Allows transfer of nonqualified funds to qualified funds



New Process Combined licensing process (10 CFR 52)



* Opportunity for public comment
 ** Opportunity for hearing

Necessary reform to attract financing

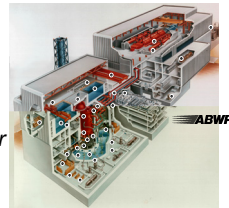
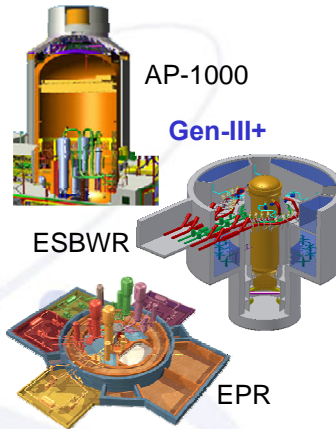
9 Years

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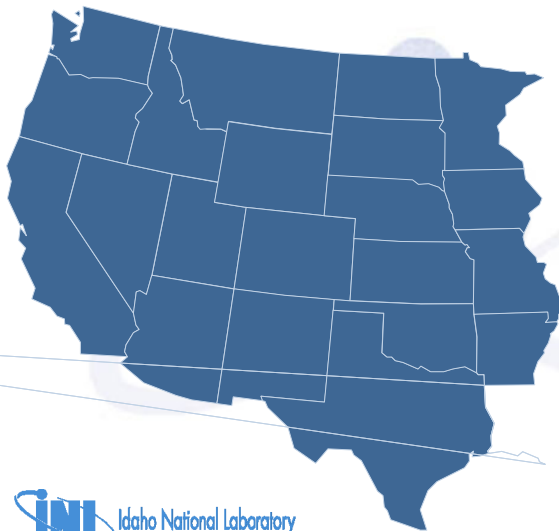


Designs competing for US market: *Generation III & III+*

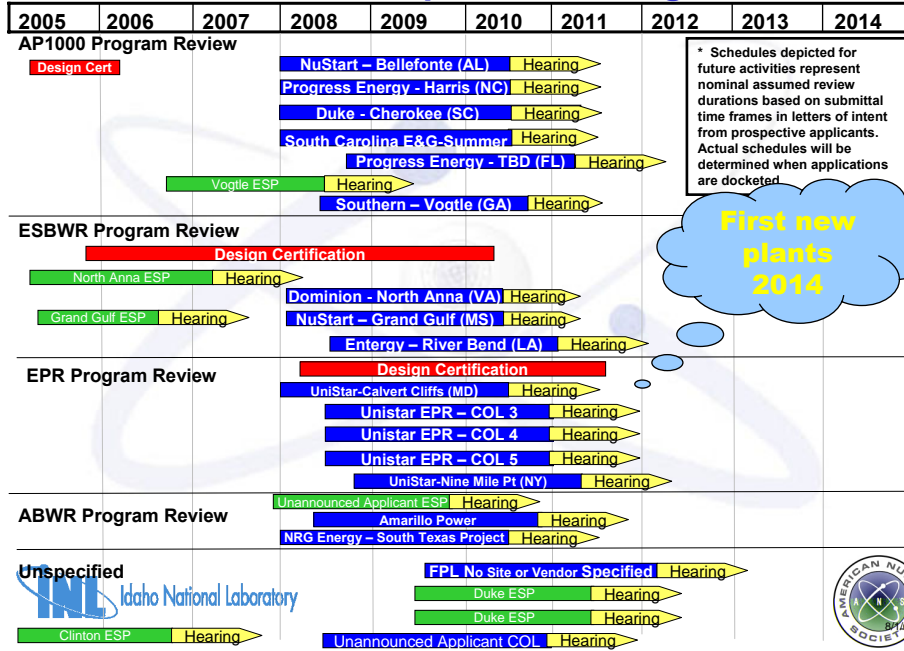
- Standardized designs based on modularization producing shorter construction schedules
- Passive or redundant systems to enhance safety
- Easier to protect from terrorist attacks



U.S. nuclear industry—first movers for new build Constellation



NRC's estimated new plant licensing schedule



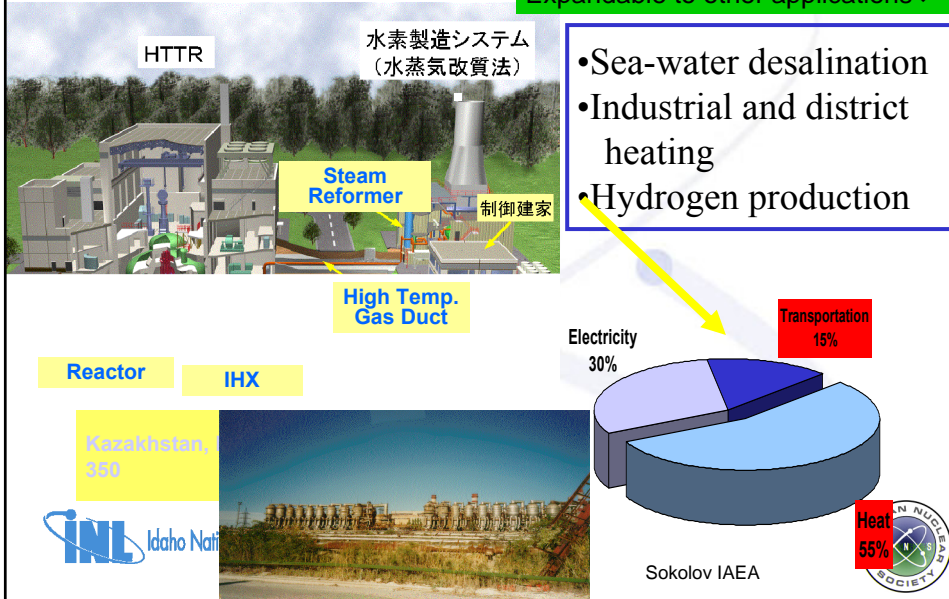
30 new nuclear plants in 2020?

New Eurostaf report says 78 additional GWe by 2030

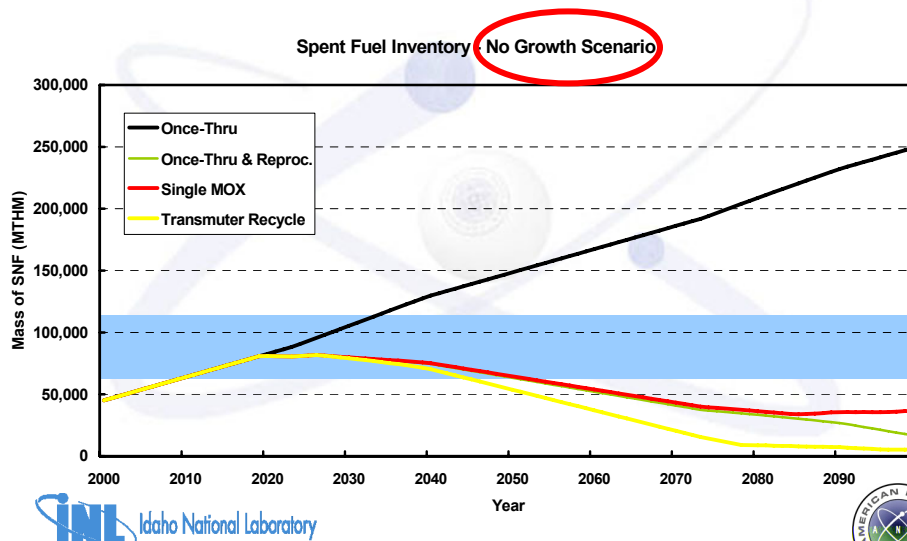


Non-electricity applications of nuclear energy

Expandable to other applications ✓

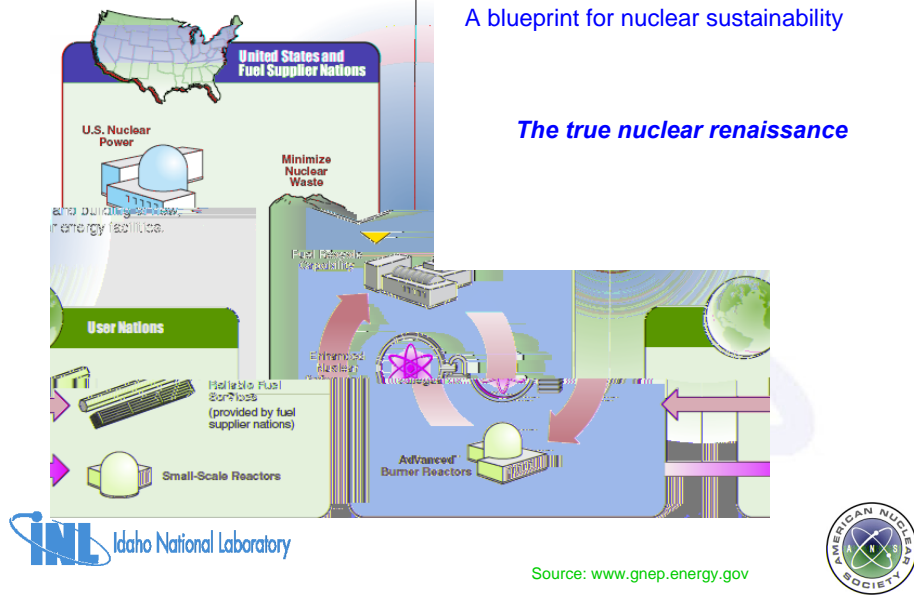


Reprocessing a logical option for growth



Global Nuclear Energy Partnership (GNEP)

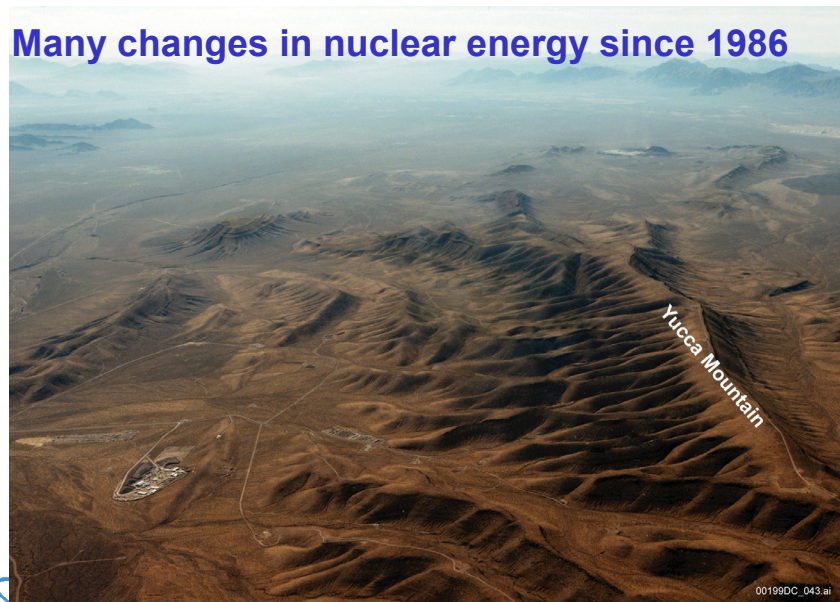
A blueprint for nuclear sustainability



Minimum conditions for a renaissance

- **Continued safe and efficient operation of existing nuclear power plants**
- Complete license extension and power uprate
- Construct, license and operate new units
- Reestablish industrial base
- Create a 21st century workforce
- Maintain public approval
- Complete the fuel cycle—get green
- Successful research, development and demonstration of advanced technologies to establish global leadership

Many changes in nuclear energy since 1986



Managing used fuel in the renaissance

- Fix nuclear policies
 - Remove the 70,000 ton cap
 - Adopt recycle
 - Lose the EPA million-year criterion
- Engineer and license the repository by stages
 - Expand to include larger area analyzed in 1999 EIS
 - Design system for actual loading
- Apply advanced technologies
 - Recycle uranium, immobilize waste, avoid proliferation

Nevada has 40 open-pit gold mines



Barrick Goldstrike Mine, Nevada

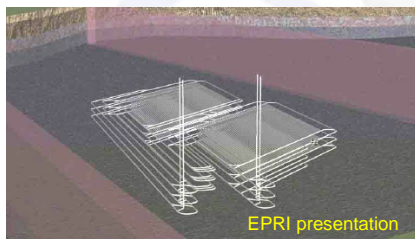
Where is the 1-million year safety standard?

Abandoned Pit Mine
refilling with water

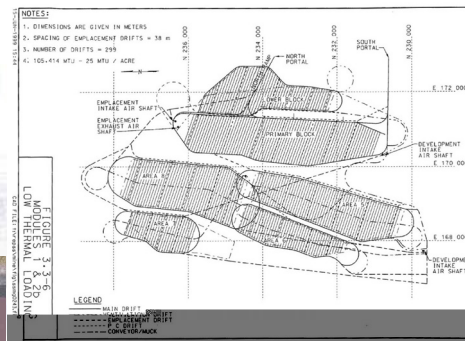
- Up to 1600 feet below the water table
- After pumping stops, take decades to centuries to refill
- Groundwater evaporation rates ~300 million gallons per year
- Concentrate selenium, arsenic, heavy metals and acid
- Long-term impacts unknown: NY Times, 12/30/05, "They will be like huge desert sponges, sucking from the aquifer eternally"

Several options to increase capacity

- Use available land
- Multi-level
- Reprocess and transmute



EPRI presentation



Per Peterson, UC Berkeley

Senator Domenici's Yucca Mountain Bill

- Authorizes DOE to withdraw 147,000 acres (BLM, USAF, NTS)
- Replaces arbitrary 70,000 ton capacity with scientifically based capacity
- Authorizes infrastructure construction after EIS
- Gives DOE authority to accept and store SNF
 - Starts with defense waste and fuel
 - After construction permit, legacy civilian fuel
- Withdraws land for rail line
- Changes “standard contract” to 25 after start of operation

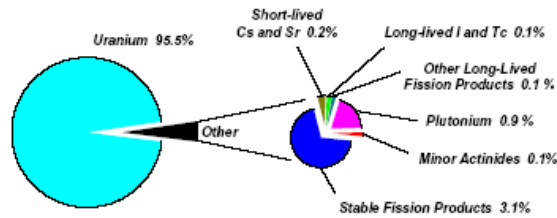


Domenici's bill, continued

- Takes Waste Fund off budget
- Requires NRC to accept legislation as satisfying waste confidence for new plant construction
- Basically the bill integrates YMP with GNEP and incorporates some recommendations of the National Academies' 2003 report on “staging”



Composition of Spent Nuclear Fuel



(Standard PWR 33GW/t, 10 yr. cooling)

1 tonne of SNF contains:

955.4 kg U
 8.5 kg Pu

Minor Actinides (MAs)

0.5 kg ^{237}Np
 0.6 kg Am
 0.02 kg Cm

Long-Lived fission Products (LLFPs)

0.2 kg ^{129}I
 0.8 kg ^{99}Tc
 0.7 kg ^{93}Zr
 0.3 kg ^{135}Cs

Short-Lived fission products (SLFPs)

1 kg ^{137}Cs
 0.7 kg ^{90}Sr

Stable Isotopes

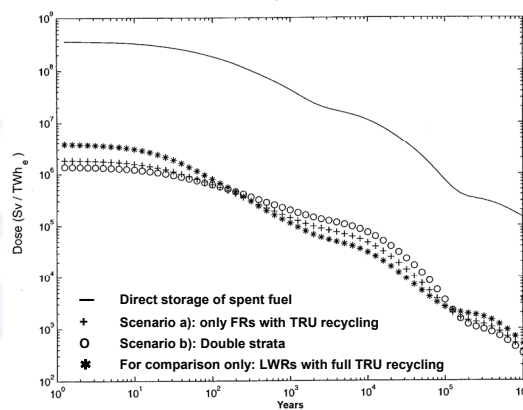
10.1 kg Lanthanides
 21.8 kg other stable



Courtesy of Max Salvatore



Radiotoxicity reduction

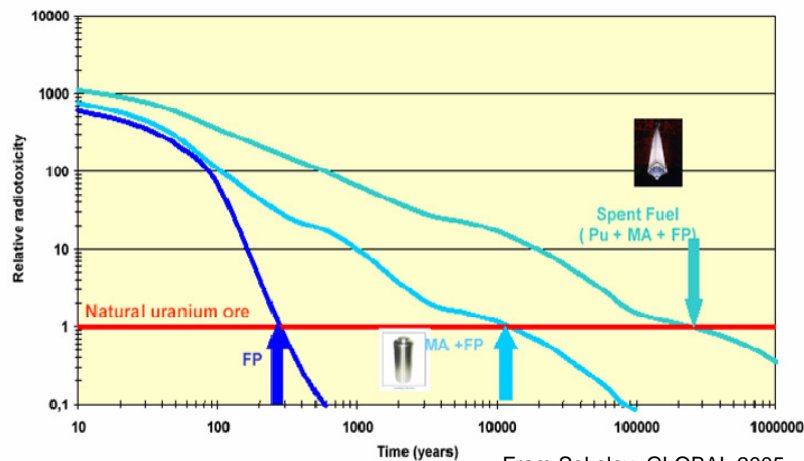


- Radiotoxicity reduction is comparable (i.e. higher than a factor 100) in transmutation scenarios a) and b), and depends on losses during reprocessing. In the cases presented here a 0.1 % value is taken for all TRU.

- However, the impact on the fuel cycle is different. It becomes unacceptably high if all TRU recycled in LWRs, due to the high neutron doses at fuel fabrication



Reprocessing reduces future risk

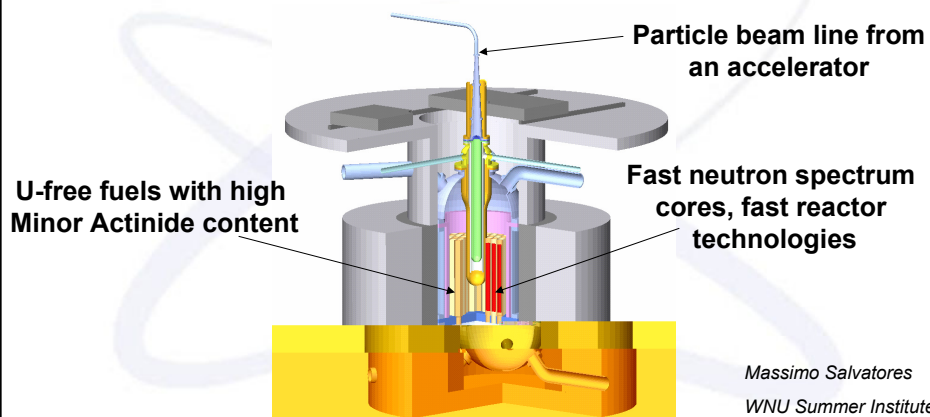


From Sokolov, GLOBAL 2005



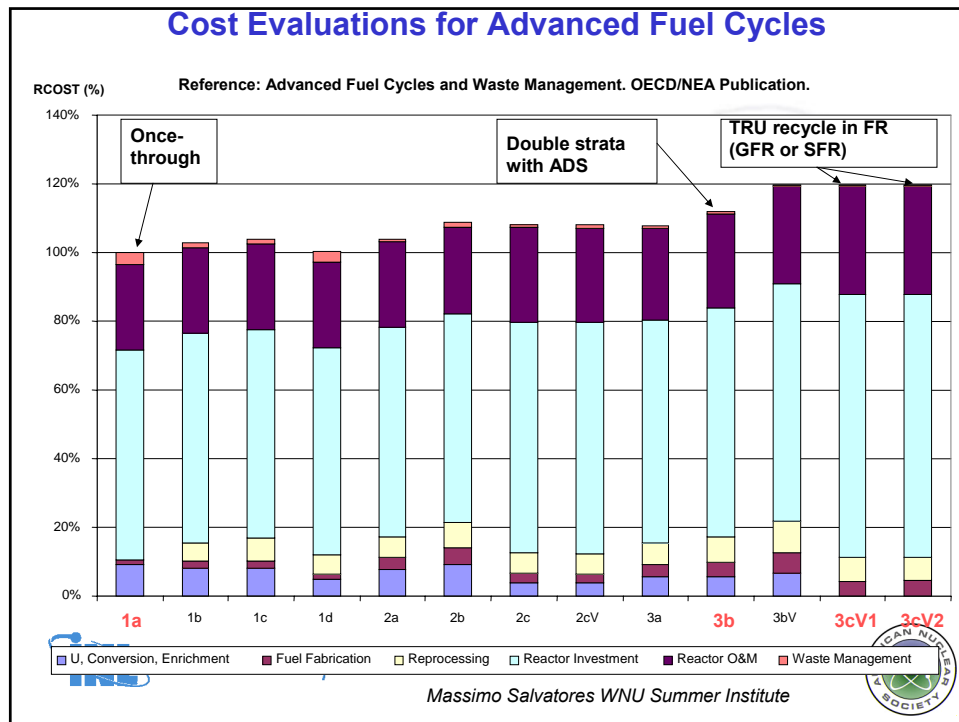
Transmutation of minor actinides requires new technology

- **Subcritical Accelerator Driven System dedicated to the transmutation of Minor Actinides**

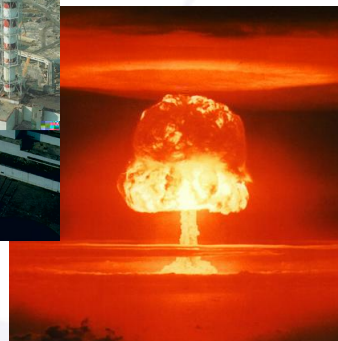
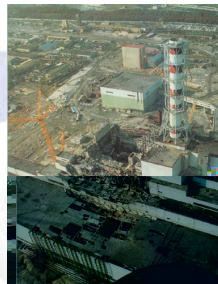


Subcriticality helps to cope with safety characteristics of MA-dominated cores





Nuclear energy policy remains in conflict



"If we're to get in step with the world effort to reduce greenhouse gases, we are going to need to rely more, not less, on carbon-free nuclear energy."
New York Times editorial April 26, 2006.

Summary

- The future promise is huge
- Nevertheless, conditions for a renaissance are fragile
- Nevada has a lynchpin role
- Nuclear plants will have 60 or more year operating lifetimes; we need to think about evolution of the system over the century



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